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(71) Applicant: THE FOXBORO COMPANY [US/US]; 33 Commercial Street, Foxboro, MA 02035 (US).

(72) Inventors: ELDRIDGE, Keith; 239 Poquanticut Avenue, North Easton, MA 02356 (US). MESKONIS, Paul; 178 Rock Street, Norwood, MA 02062 (US). HALL, Robert; 37 Dean Street, South Easton, MA 02375 (US). BURKE, Kenneth, A.; 254 Purchase Street, South Easton, MA 02375 (US). VOLK, Scott; 25 Ramblewood Drive, North Easton, MA 02356 (US). JOHNSON, Mark; 254 Old Wood Road South, North Attleboro, MA 02760 (US). MACKAY, Brian; 335 Cove Drive, Coppell, TX 75019-5679 (US). DARDINSKI, Steven; 7 Vose Hill Road, Westford, MA 01886 (US).

(74) Agents: POWSNER, David, J. et al.; Nutter, McClennen & Fish, LLP, One International Place, Boston, MA 02110-2699 (US).

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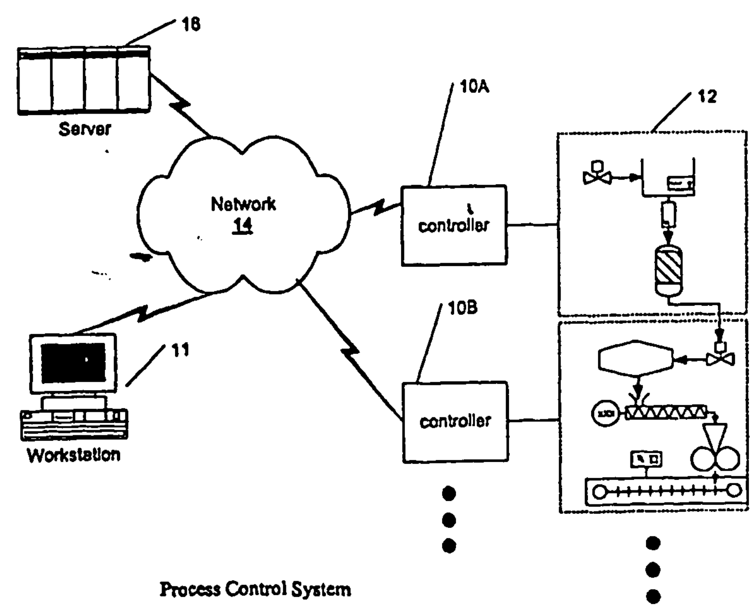
(54) Title: METHODS AND APPARATUS FOR CONTROL CONFIGURATION WITH VERSIONING, SECURITY, COMPOSITE BLOCKS, EDIT SELECTION, OBJECT SWAPPING, FORMULAIC VALUES AND OTHER ASPECTS

(57) Abstract



Process Control System

Methods and apparatus for configuring process, environmental, industrial and other control systems generate and/or utilize models representing configurations of control systems and/or the systems controlled by them. Records of changes to the models or the configurations represented by them are maintained, thereby, for example, providing bases for determining current states, prior states and histories of changes. Objects in the model have characteristics, such as an object type characteristic and an area characteristic. Users can have corresponding permissions. A security mechanism apparatus controls access by users to the objects. Composite objects are defined by definition objects and are displayed in encapsulated or expanded formats. Objects can include an edit control type identifier that determines how they are presented for editing. Functionality responds to user commands by transferring characteristics of a first object depicted by the graphical user interface to a second object. Configuration-time formulas contained objects are evaluated to constants prior to downloading to the control system.

METHODS AND APPARATUS FOR CONTROL CONFIGURATION WITH VERSIONING, SECURITY, COMPOSITE BLOCKS, EDIT SELECTION, OBJECT SWAPPING, FORMULAIC VALUES AND OTHER ASPECTS

Reference to Related Applications

This application claims the benefit of priority of U.S.S.N. 60/134,597, filed May 17, 1999, entitled INTEGRATED DESIGN AUTOMATION CONTROL ALGORITHM CONFIGURATOR ARCHITECTURE (Attorney Docket: 102314-0045), the teachings of which are incorporated herein by reference.

This application is a continuation of copending, commonly assigned U.S.S.N. 09/448,845, filed November 23, 1999, entitled METHODS AND APPARATUS FOR CONTROLLING OBJECT APPEARANCE IN A PROCESS CONTROL CONFIGURATION SYSTEM (Attorney Docket: 102314-50), the teachings of which are incorporated herein by reference.

This application is a continuation of copending, commonly assigned U.S.S.N. 09/448,223, filed November 23, 1999, entitled PROCESS CONTROL CONFIGURATION SYSTEM WITH CONNECTION VALIDATION AND CONFIGURATION (Attorney Docket: 102314-54), the teachings of which are incorporated herein by reference.

This application is a continuation of copending, commonly assigned U.S.S.N. 09/448,374, filed November 23, 1999, entitled PROCESS CONTROL CONFIGURATION SYSTEM WITH PARAMETERIZED OBJECTS (Attorney Docket: 102314-46), the teachings of which are incorporated herein by reference.

Background of the Invention

The invention pertains to control and, more particularly, to methods and apparatus for configuring control systems.

The terms "control" and "control systems" refer to the control of a device or system by monitoring one or more of its characteristics. This is used to insure that output, processing, quality and/or efficiency remain within desired parameters over the course of time. In many control systems, digital data processing or other automated apparatus monitor a device, process or system and automatically adjust its operational parameters. In other control systems, such apparatus monitor the device, process or system and display alarms or other indicia of its characteristics, leaving responsibility for adjustment to the operator.

Control is used in a number of fields. Process control, for example, is typically employed in the manufacturing sector for process, repetitive and discrete manufactures, though, it also has wide application in utility and other service industries. Environmental control finds application in residential, commercial, institutional and industrial settings, where temperature and other environmental factors must be properly maintained. Control is also used in articles of manufacture, from toasters to aircraft, to monitor and control device operation.

Modern day control systems typically include a combination of field devices, control devices, and controllers, the functions of which may overlap or be combined. Field devices include temperature, flow and other sensors that measure characteristics of the device, process or system being controlled. Control devices include valves, actuators, and the like, that control the device, process or system itself.

Controllers generate settings for the control devices based on measurements from the field devices. Controller operation is typically based on a "control algorithm" that maintains a controlled system at a desired level, or drives it to that level, by minimizing differences between the values measured by the sensors and, for example, a setpoint defined by the operator.

In a food processing plant, for example, a controller can be used to maintain a soup stock at a simmer or low boil. This is done by comparing measurements of vapor pressure in the processing vessel with a desired setpoint. If the vessel pressure is too low, the control algorithm may call for incrementally opening the heating gas valves, thereby, driving the pressure and boiling activity upwards. As the pressure approaches the desired setpoint, the algorithm requires incrementally leveling the valves to maintain the roil of the boil.

Controllers may be networked or otherwise connected to other computing apparatus that facilitate monitoring or administration. The so-called S88 industry standard, described in <u>Batch Control - Part 1: Models and Terminology</u> (The International Society for Measurement and Control 1995), for example, defines a hierarchy of processing and control equipment ("equipment entities") that can be used to model and control an automated manufacturing process. At the lowest level of the hierarchy are control modules that directly manipulate field devices (e.g., opening and closing valves) and, possibly, other control modules. At a higher level, equipment modules coordinate the functions control modules, as well as of other equipment modules, and may execute phases of the manufacturing process (such as setting controller constants and modes). "Units," at still a higher level of the hierarchy, coordinate the functions of equipment and control modules. Process cells orchestrate all processing activities required to produce a manufacturing batch, e.g., scheduling, preparing and monitoring equipment or resources, and so forth.

The principal function of controllers is executing control algorithms for the real-time monitoring and control of devices, processes or systems. They typically have neither the computing power nor user interfaces required to facilitate the design of a control algorithm. Instead, the art has developed configurators. These are typically general purpose computers (e.g., workstations) running software that permit an engineer or operator to graphically model a device, process or system and the desired strategy for controlling it. This includes enumerating field devices, control devices, controllers and other apparatus that will be used for control, specifying their interrelationships and the information that will be transferred among them, as well as detailing the calculations and methodology they will apply for purposes of control. Once modeling is complete and tested, the control algorithm is downloaded to the controllers.

One well known process control system configurator is that provided with the I/A Series® (hereinafter, "IAS" or "I/A") systems, marketed by the assignee hereof. These provide a graphical interface (FoxCAE) permitting an engineer to model a process hierarchically and to define a control algorithm from that hierarchy. Multiple editors are provided for defining and modifying modules within the hierarchy.

Though prior art process control configuration systems, particularly, the IAS systems and others sold by the assignee hereof, have met wide acceptance in the industry, there remains room for improvement. Such is the case, for example, with respect to the configuration of complex control systems.

In this context, an object of the present invention is to provide improved methods and apparatus for control and, particularly, for configuring control systems. A related object of the invention is to provide methods and apparatus for configuring a process control systems.

A further object of the invention is to provide such methods and apparatus as facilitate configuring large or complex control systems

Still yet a further object of the invention is to provide such methods and apparatus as can be used in configuring a range of control systems, whether hierarchical or not, whether pertaining to process control or otherwise.

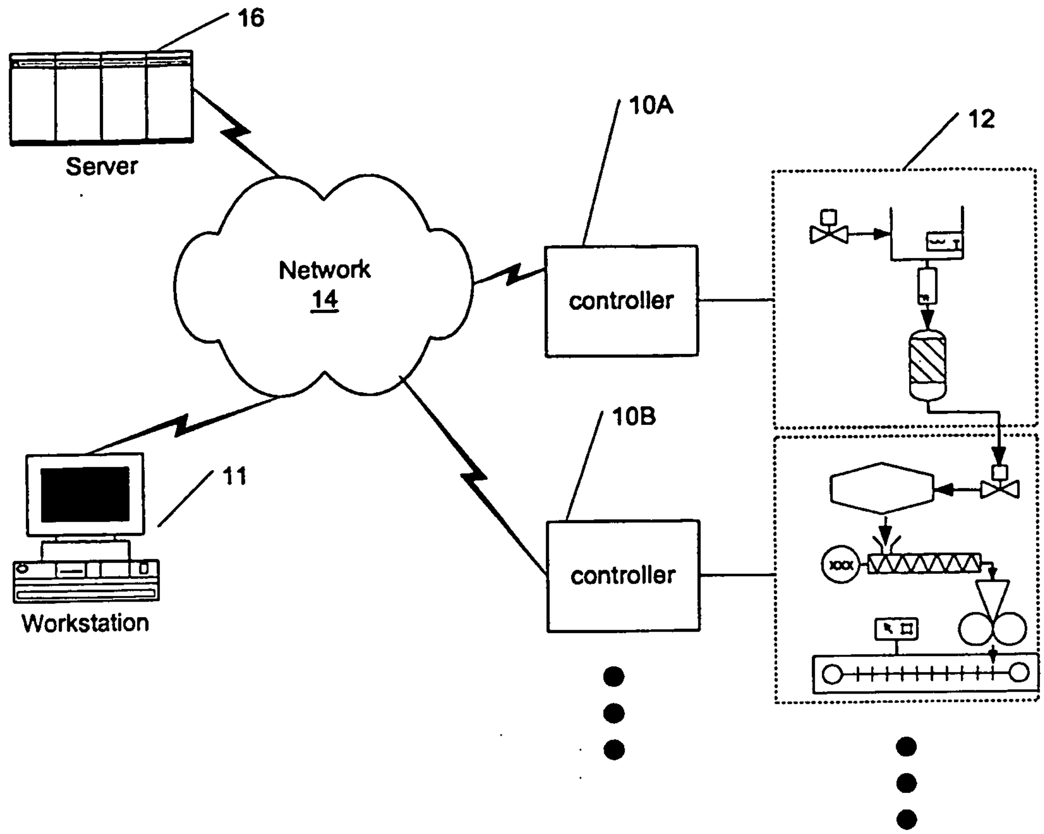


Figure 1 - Process Control System

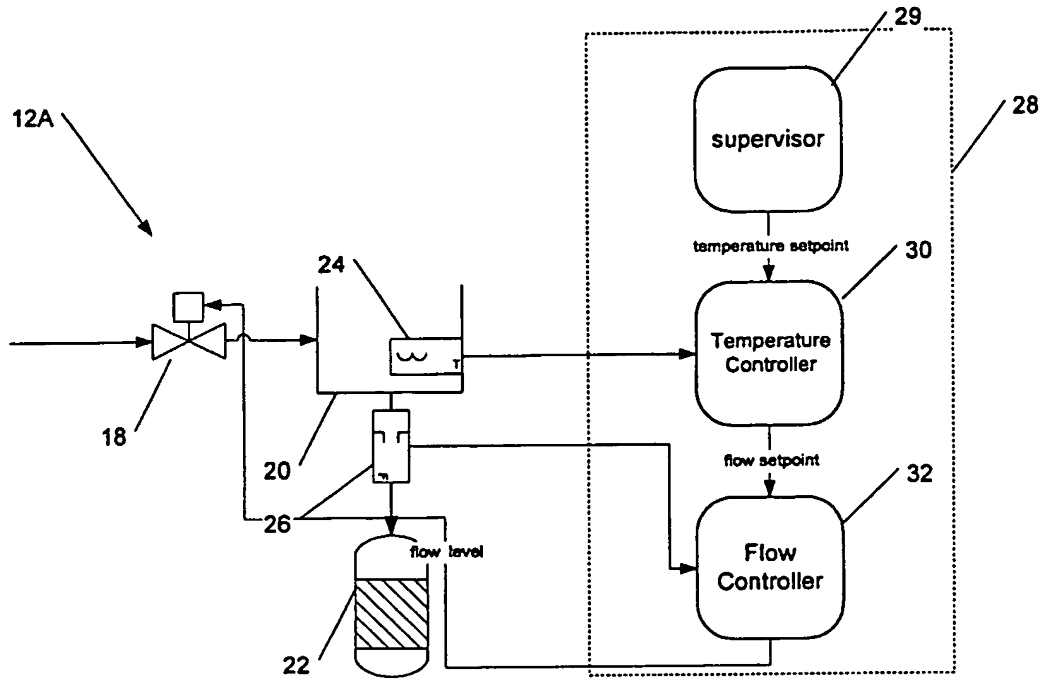


Figure 2 - Exemplary Controlled Process

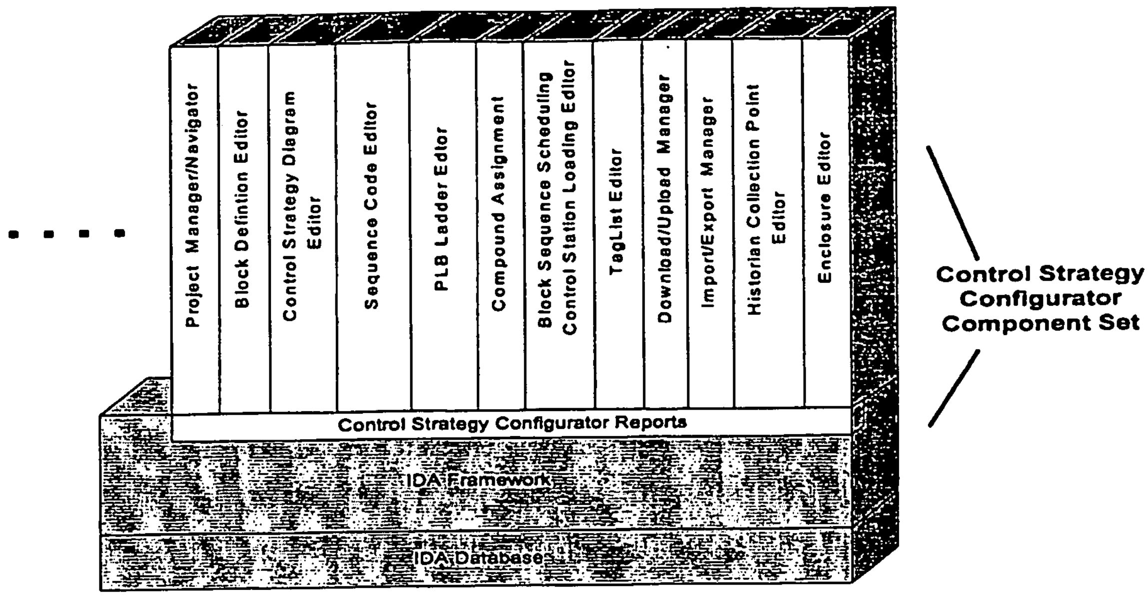


Figure 3 - Control Strategy Configurator Components

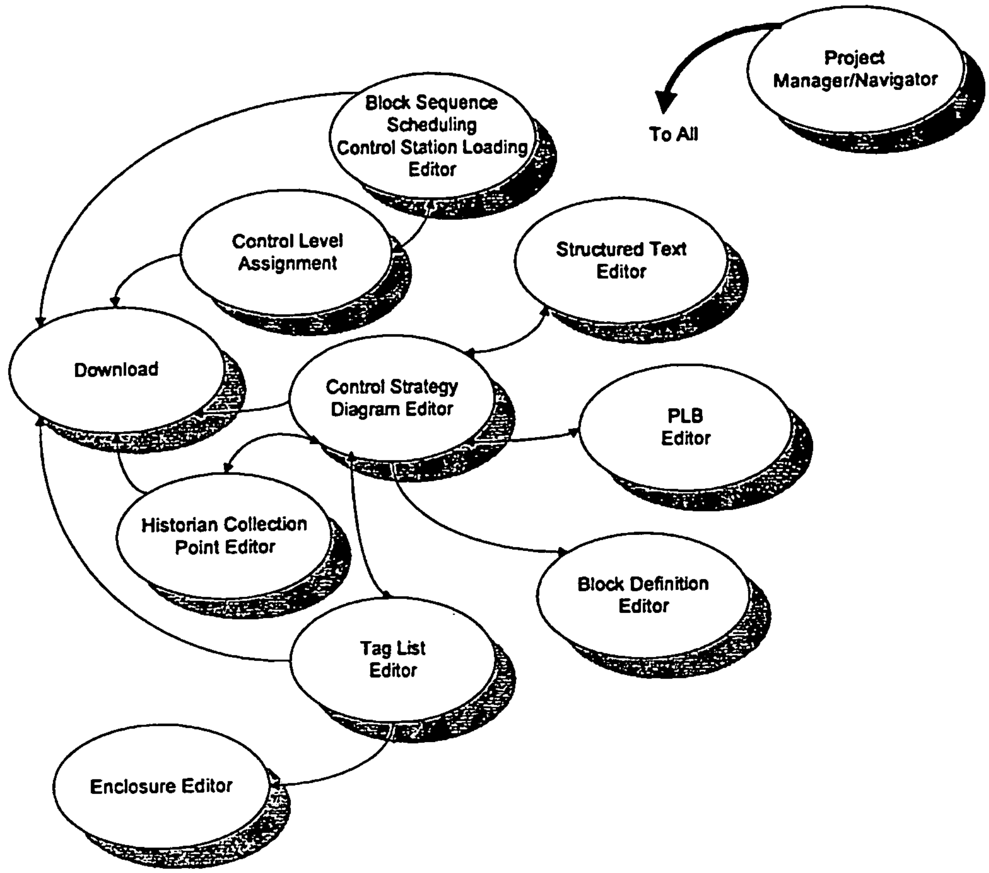


Figure 4 - Component Interaction Diagram

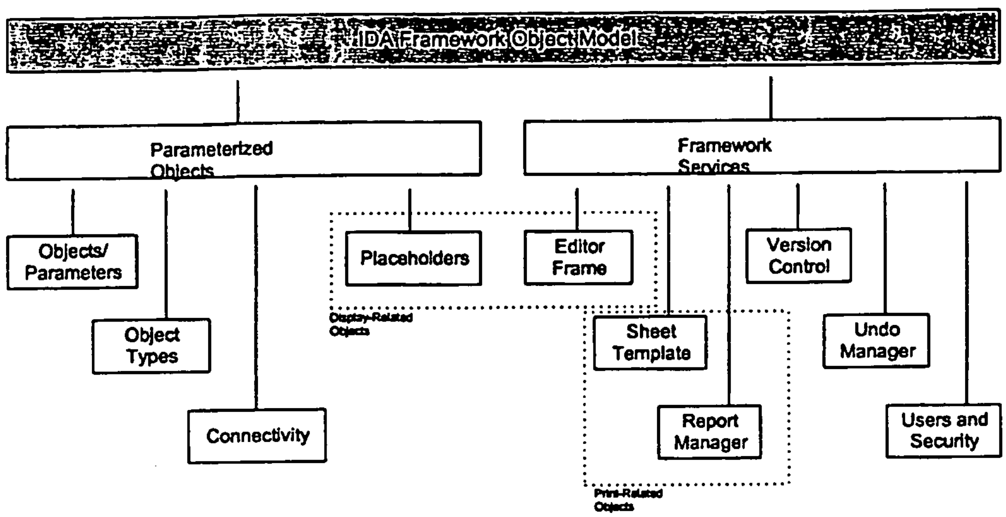


Figure 5 - IDA Framework Object Model Components

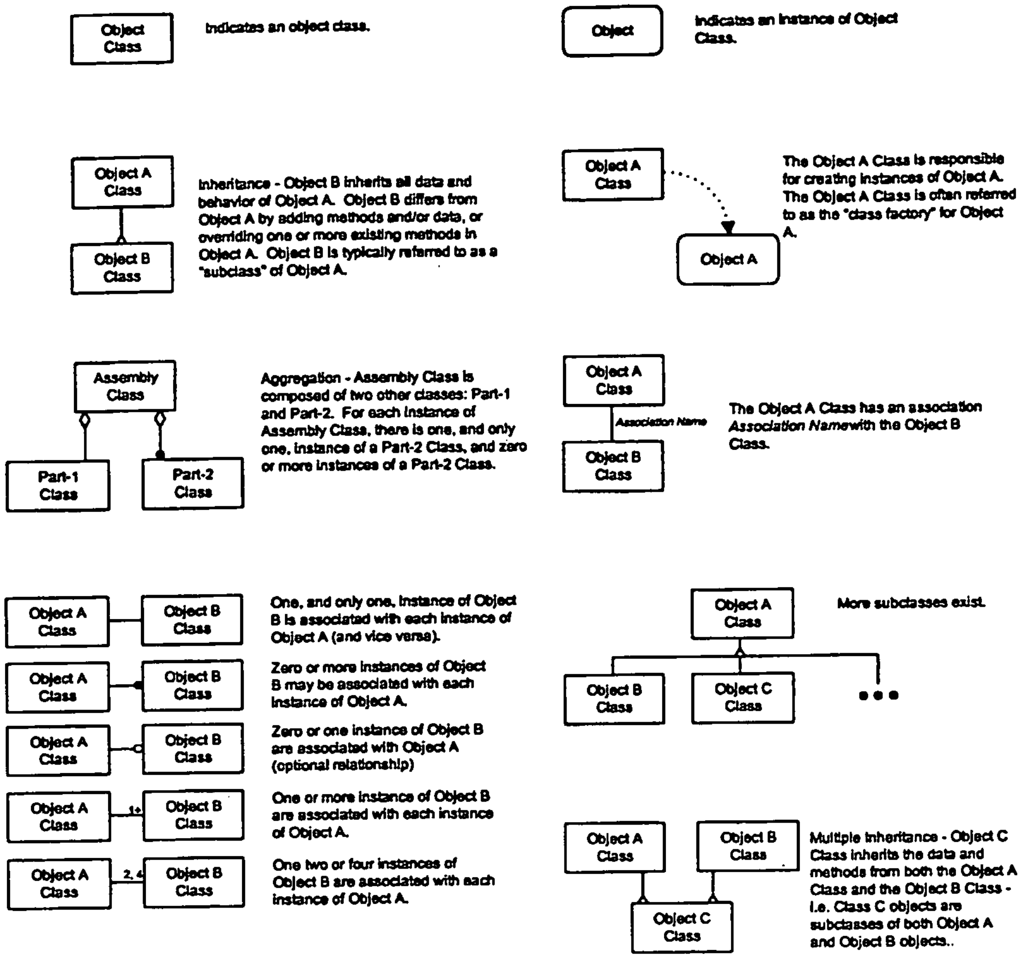


Figure 6 - Object Model Notation Conventions

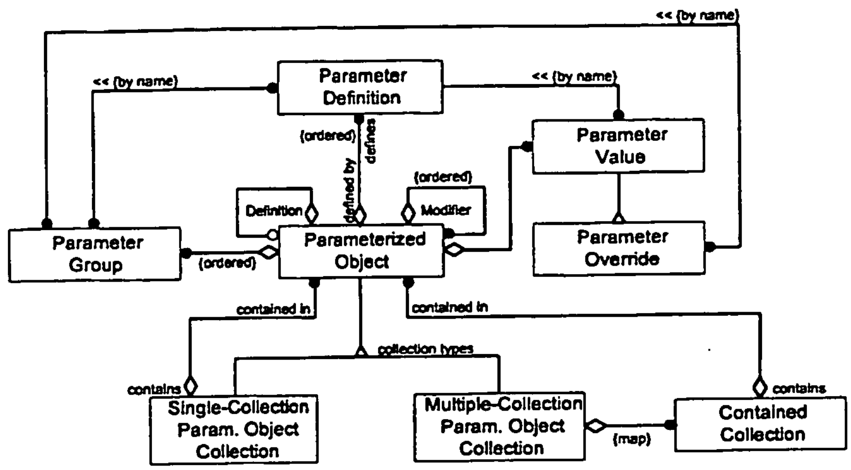


Figure 7 - Parameterized Object Model

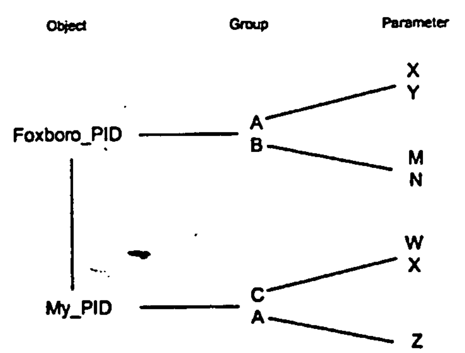


Figure 8 - Parameter Group Inheritance

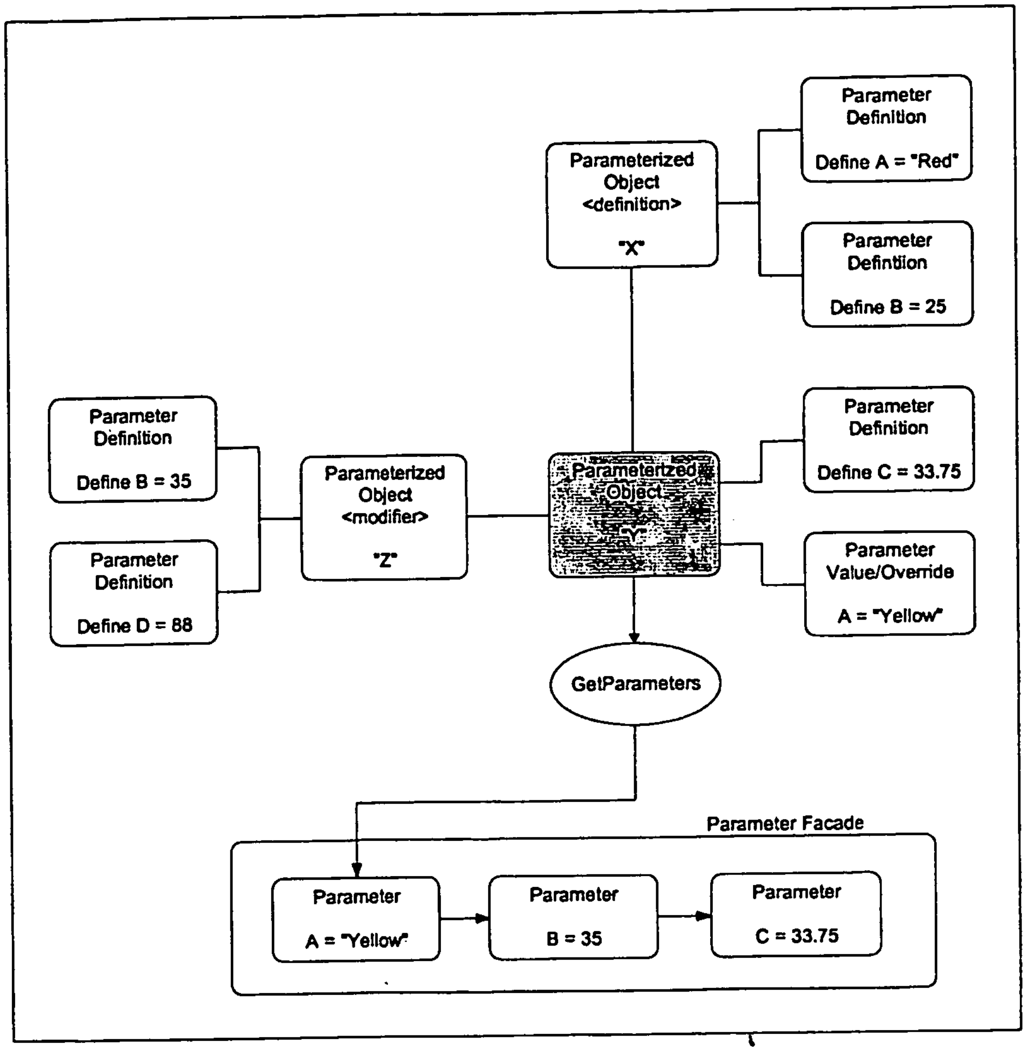


Figure 9 - Parameterized Object Example

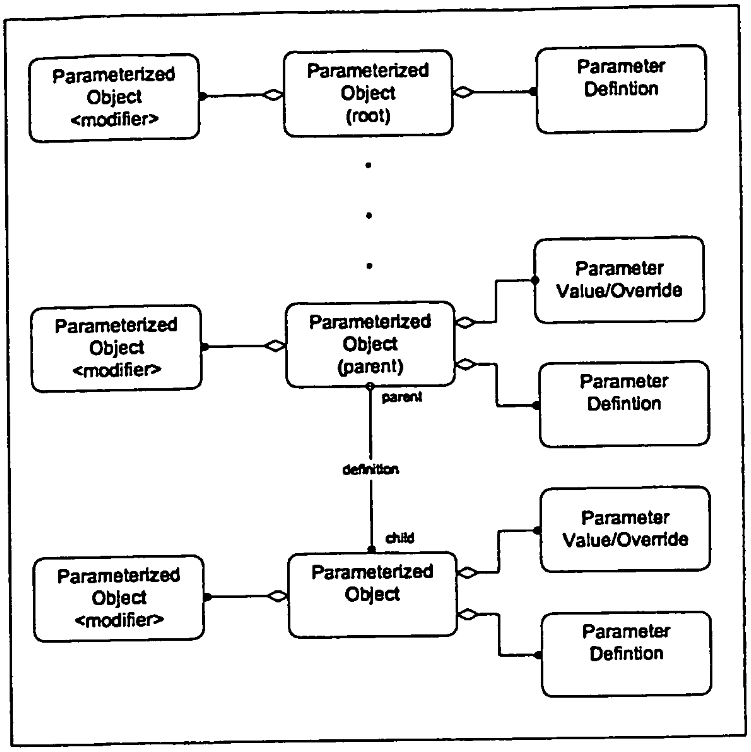


Figure 10 - Creating A Parameter List

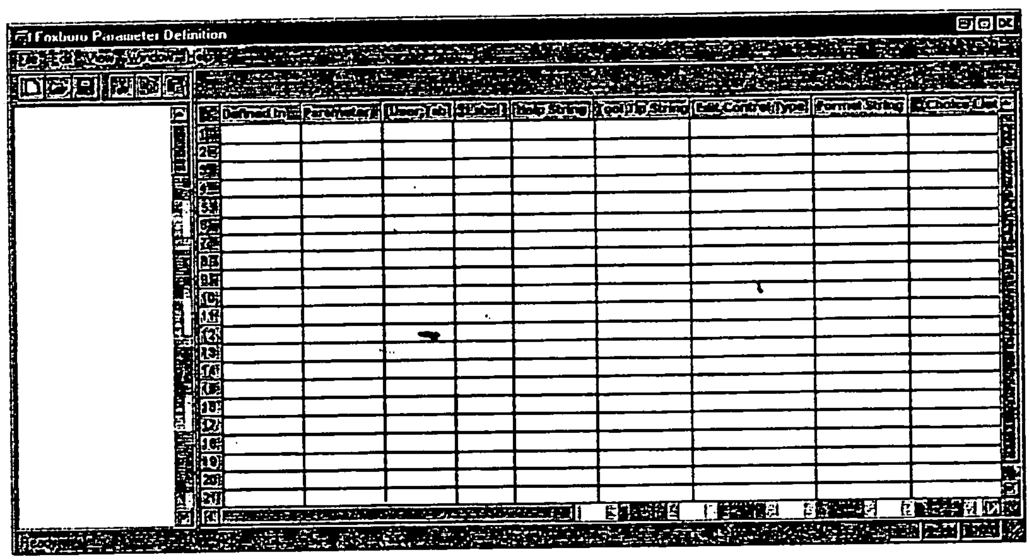


Figure 11 - Parameter Definition Editor

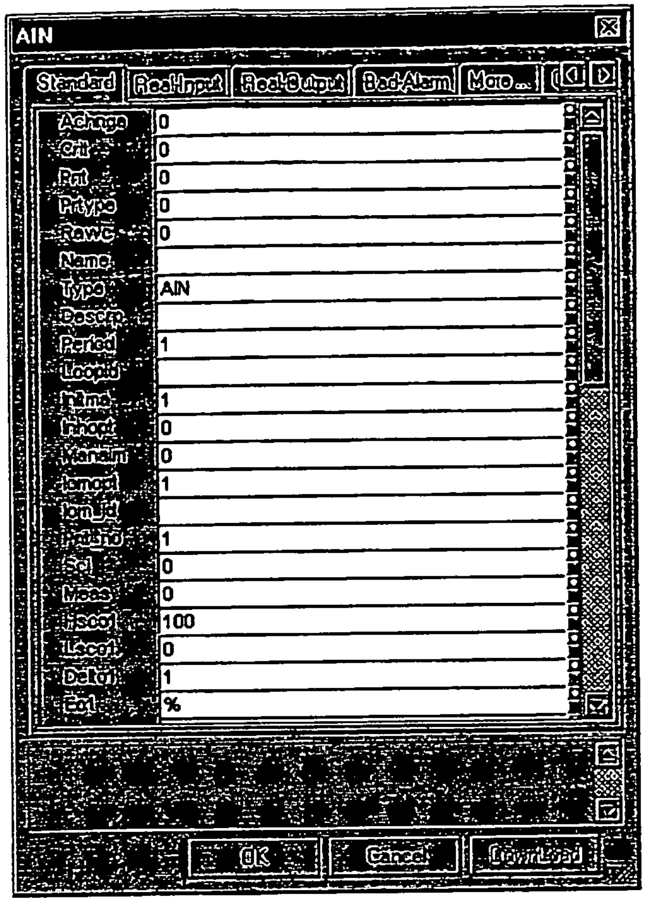


Figure 12 - Parameter Editor Example

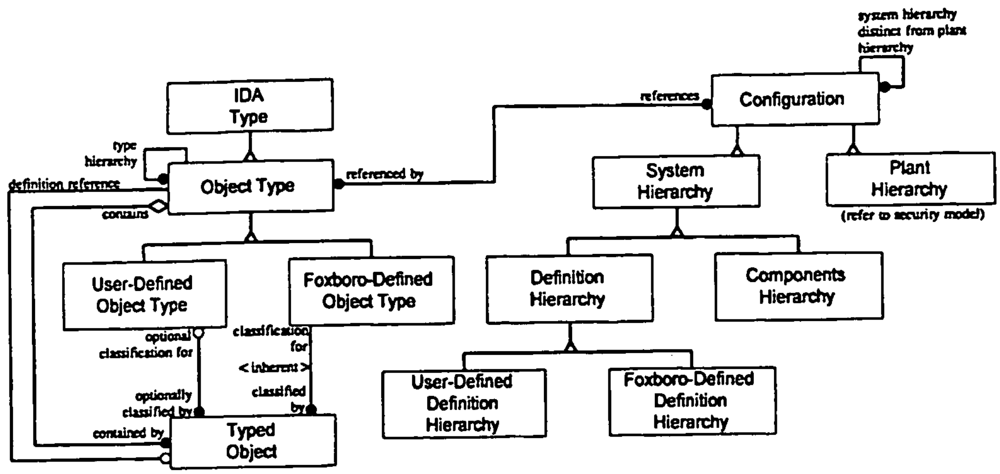


Figure 13 - Object Types

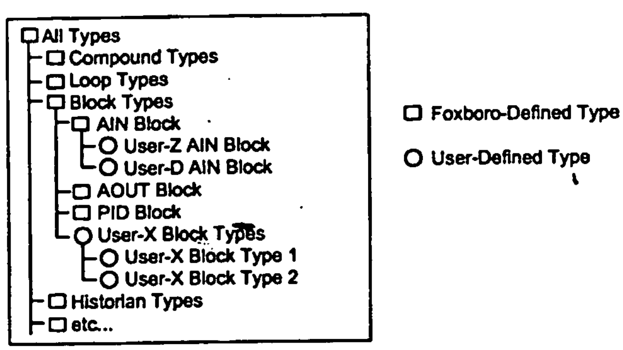


Figure 14 - Object Type Hierarchy Example

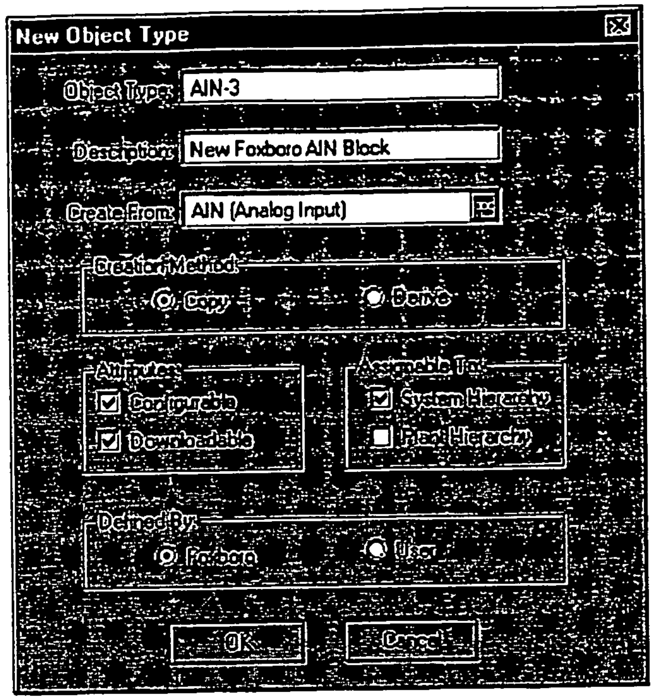


Figure 15 - Creating New Object Types

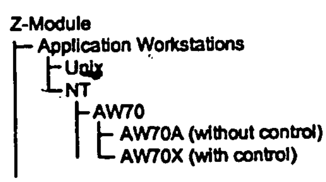


Figure 16 - Type Awareness Example

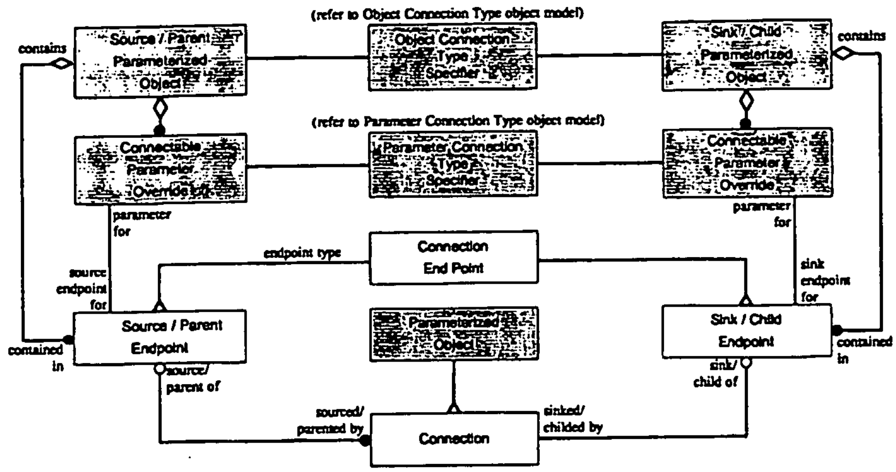


Figure 17 - Connection Object Model

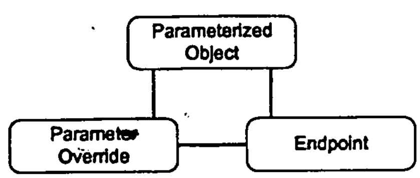


Figure 18 - Parameterized Object - Override - Endpoint Triad

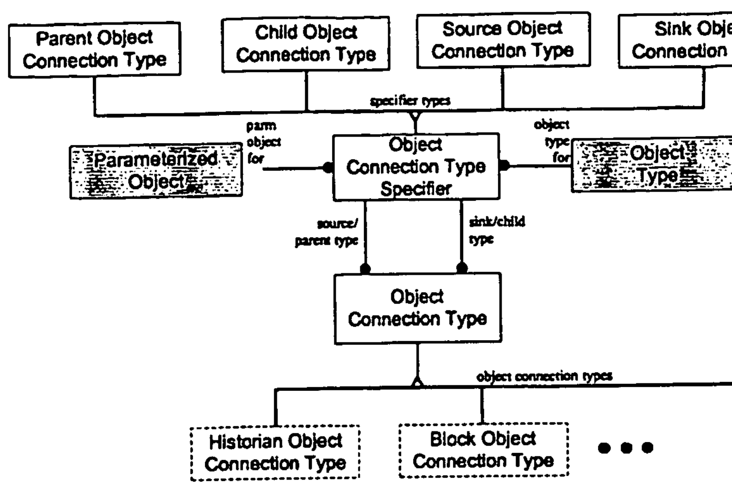


Figure 19 - Object Connection Type Object Model

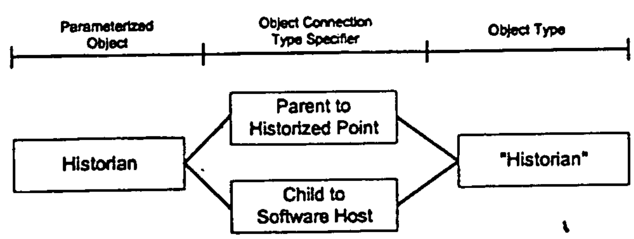


Figure 20 - Example of Simultaneous Parent/Child Object Connectivity

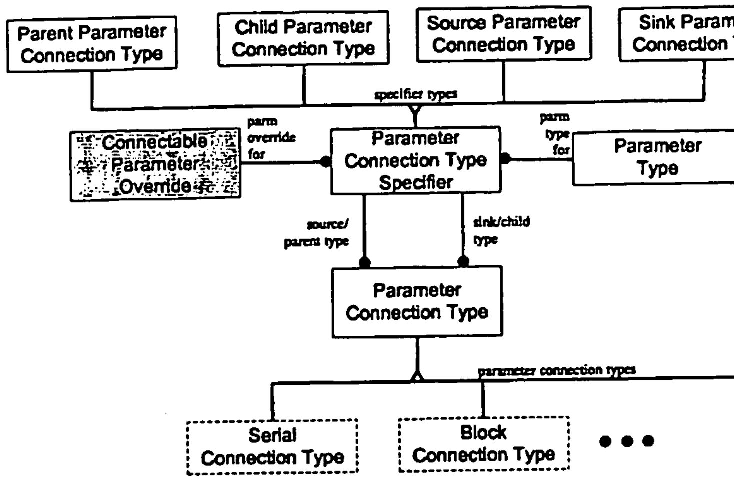


Figure 21 - Parameter Connection Type Object Model

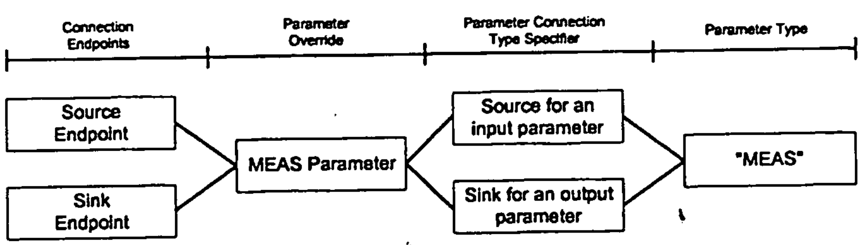


Figure 22 - Example of Simultaneous Source/Sink Parameter Connectivity

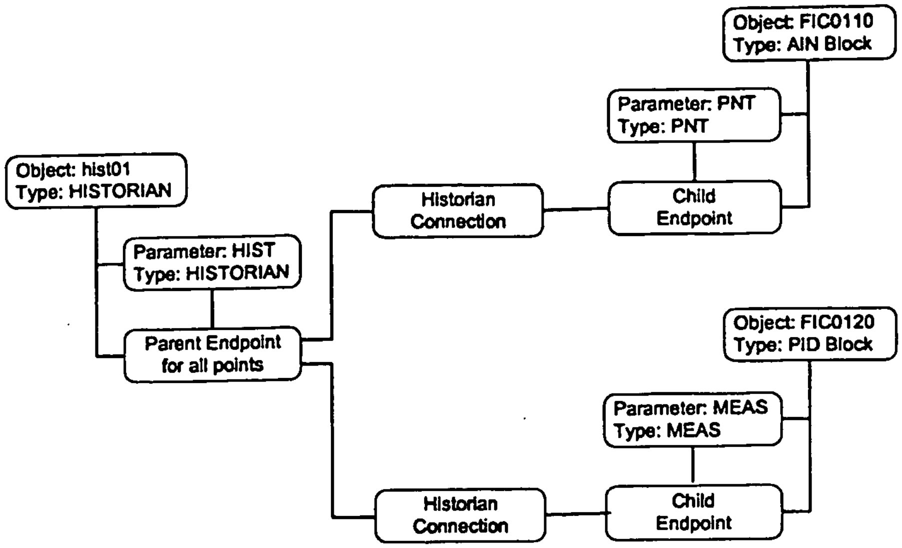


Figure 23 - Parent/Child Connectivity Example - Case #1

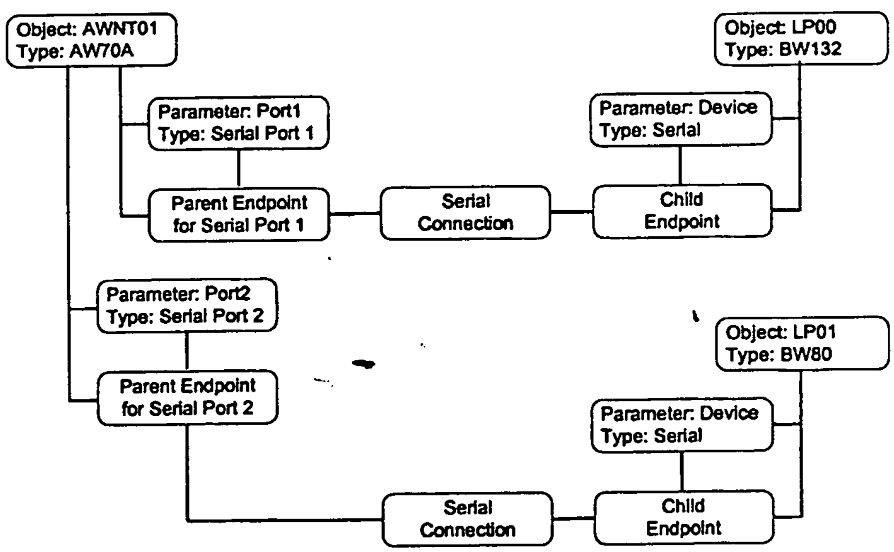


Figure 24 - Parent/Child Connectivity Example - Case #2

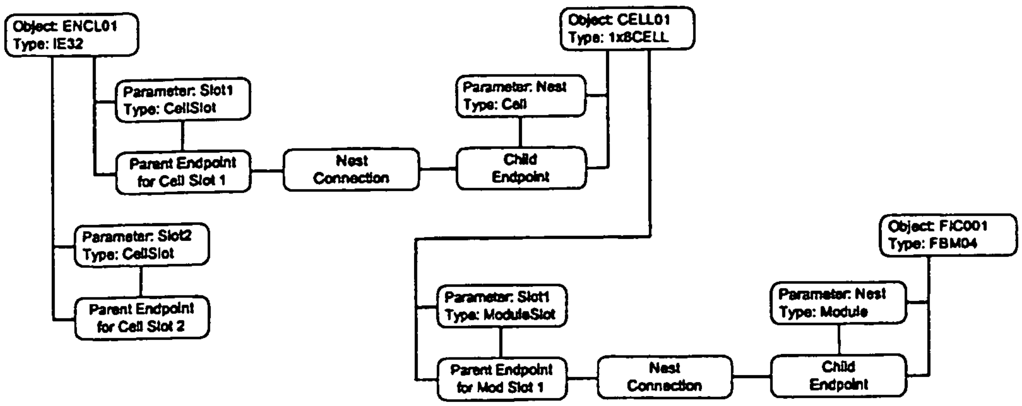


Figure 25 - Parent/Child Connectivity Example (Nest) - Case #3

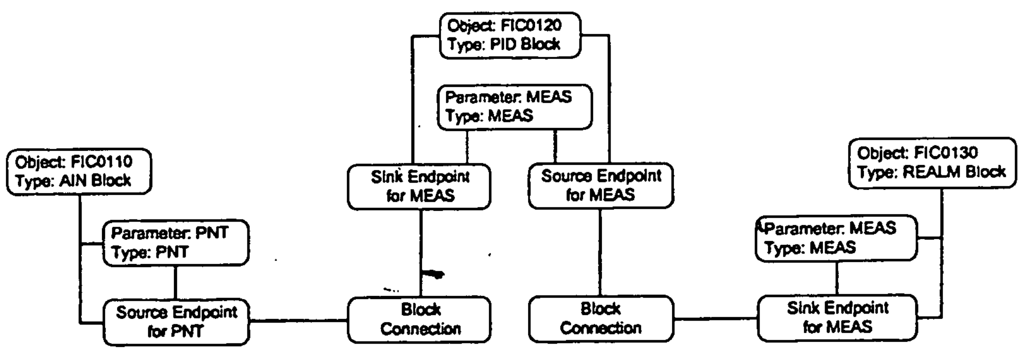


Figure 26 - Source/Sink Connectivity Example

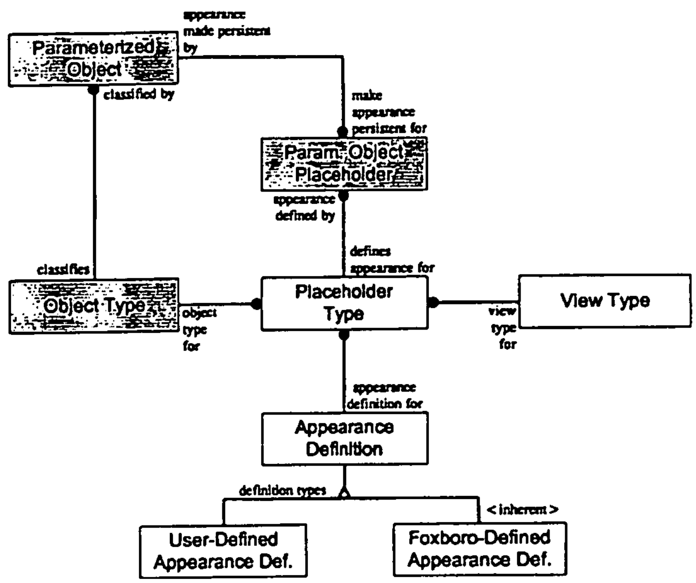


Figure 27 - Appearance Object Model

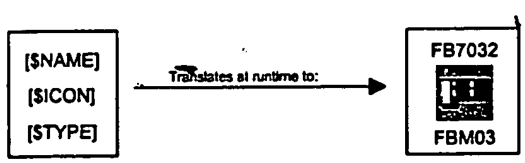


Figure 28 - Appearance Definition Example

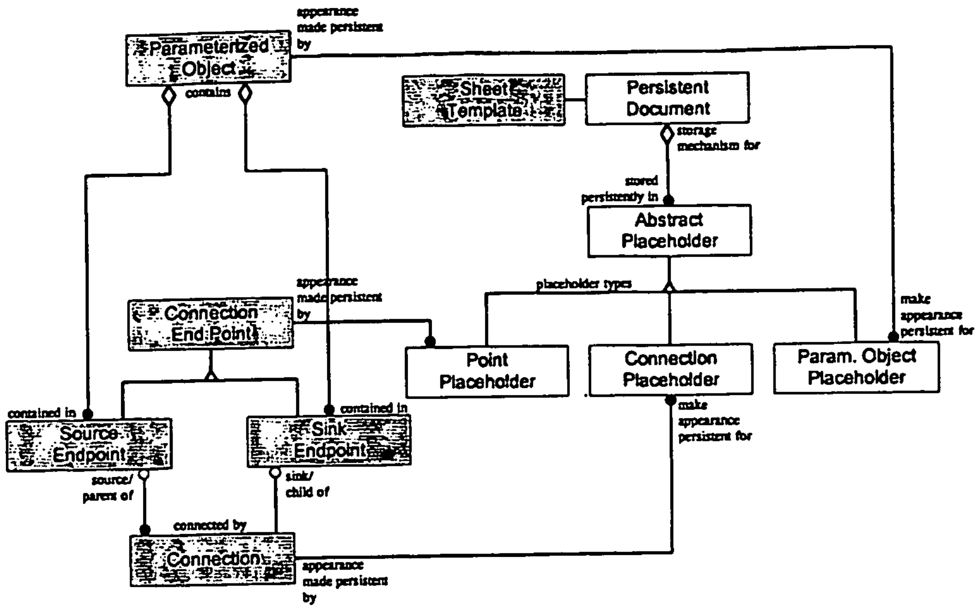


Figure 29A - Placeholders Object Model

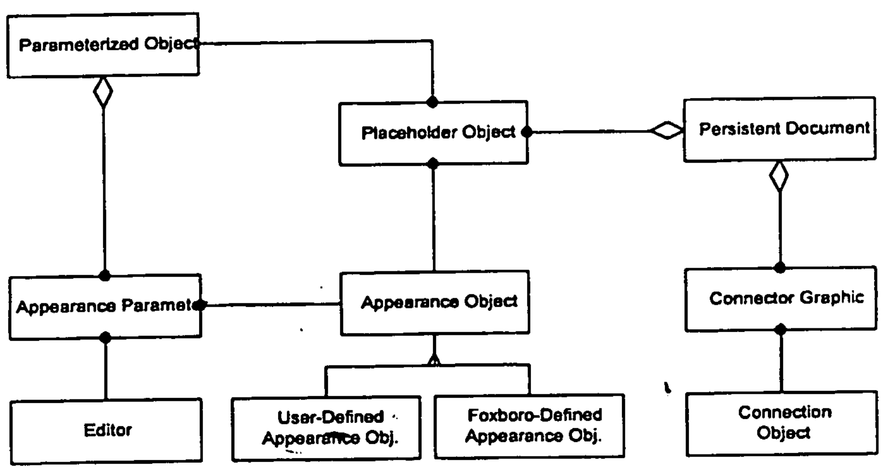


Figure 29B - Combined Placeholder/Appearance Object Model

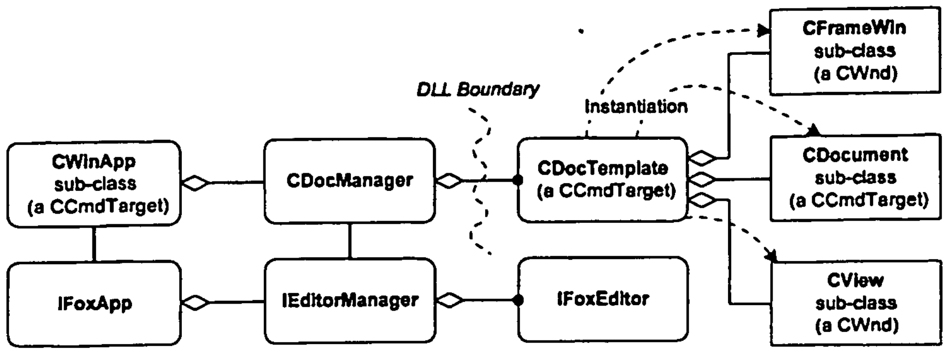


Figure 30 - MFC Document/View Architecture

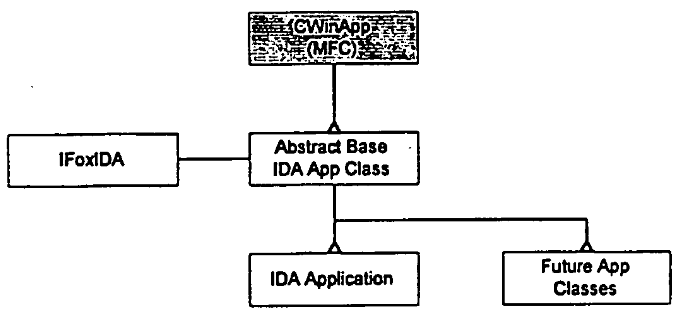


Figure 31 - The IDA Application Class Architecture

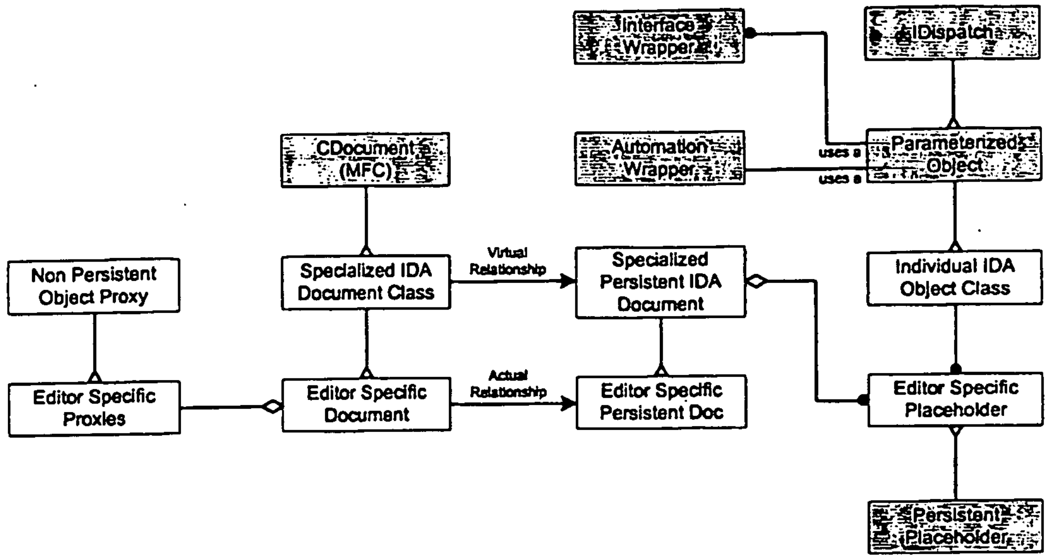


Figure 32 - The IDA Document Architecture